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Monitoring of patent's electrical characteristics.

The invention relates to medical monitoring systems. In particular, the invention relates to the method as defined in the preamble of claim 1.

FIELD OF THE TECHNIQUE

Methods for monitoring the electric activity of a patient are becoming common. Previously known is a method for measuring the electrocardiogram (EKG). In measuring, electrodes are attached to the patient, and a small high-frequency current is conducted into them. By measuring the change in the voltage of the electrodes it is possible to observe the electric activity of the patient, and e.g. the muscle activity.

Previously known is a system for EKG monitoring as schematically represented in Figs. 1 and 2. In both figures, two pictures of a torso schematically represent the same patient P, the first of which shows a standard placement of the measuring electrodes RA, LA, RL, and LL (so-called limb leads) for a 5-lead EKG and impedance respiration measurement. For the sake of clarity, the latter figure shows the standard placement of the electrodes V_1, V_2, V_3, V_4, V_5, V_6 of the EKG measurement on the patient´s chest as being separate. Together the RA, LA, RL, LL and V_1, V_2, V_3, V_4, V_5, V_6 form a so-called 12-switched switching system. The 5-switched switching system also used in the EKG measuring consists of the electrodes RA, LA, RL, LL, and V_5.

The 12-switched system as shown in Figs. 1 and 2 comprises signal conductors which are connected, according to the standard placement of electrodes, to the corresponding aforementioned measuring electrodes RA, LA, RL, LL, V_1, V_2, V_3, V_4, V_5, V_6 attached to the patient P. Each signal conductor comprises a connector apparatus. The signal conductors are further connected to the EKG equipment making the measurement.

The EKG monitoring and the diagnostic, so-called 12-switched (10-lead) EKG, has been traditionally carried out with separate equipment so that the monitoring took place with a 3- and 5-lead equipment constantly, and the 12-switched usually under the supervision of a cardiologist as a separate event, if necessary.

In the electrocardiogram, and especially in the electroencephalogram (EEG), it is important to monitor the impedance of the electrodes attached to the patent in order to ensure a good quality of the signal. Usually this happens by conducting a small high-frequency current (20-200 kHz) into the electrodes, and by measuring the voltage. In addition, it is common to monitor the respiratory movements of the patient´s chest by measuring the small changes in the impedance of the chest. The impedance measurement is also a known method in the estimation of the stroke volume of the heart or changes in it. The principles of the impedance cardiography method have been presented e.g. in the book "Principles and Practice of Intensive Care Monitoring", Martin J. Tobin, McCraw-Hill 1998, ISBN:007-0650942, pages 915-921, to which reference is made herein.

The advantage with the impedance measurement is its simplicity, and that the stroke volume of the heart can be measured continuously and rapidly non-invasively. The disadvantage with the measurement is, however, its inaccuracy, which is due to the correction factors used in empirical formulas which are based on defaults. For example, the weight of the patient, position, the placement of the electrodes, and other corresponding factors have effect on the measurement result. The impedance cardiography is very sensitive to the concentration of fluid of the human body, fatness, and position.

It is possible to utilize the EEG in anesthesia. Then, by observing the diagram produced by the EKG it is possible to ensure the level of anesthesia of the patient. There is a short preamble of the above-mentioned technique presented in the article "A Primer for EEG Signal Processing in Anesthesia", Ira J. Rapil, American Society of Anesthesiologists Inc. 1998, pages 980-1002, to which reference is made herein.

One specific problem is becoming the making of measurements e.g. in a small operating room. The prior-art measuring equipment only makes one measurement each. In that case, several devices are needed to make the measurements, in which case the operating room gets filled up with expensive measuring equipment very soon.

Previously known is a solution in which the measurements of the electric activity of a patient are made by a separate device each. The disadvantage with the solution is that in order to make several measurements, several devices are needed. The devices cannot share the conductor connections either, so each device shall have its own conductors and electrodes. On the other hand it is possible to change the conductors and electrodes between the measurement devices, but this is often complicated in an urgent operation.

OBJECTIVE OF THE INVENTION

The objective of the present invention is to eliminate or at least to alleviate the problems referred to above. One further objective of the invention is to enable two or three measurements with one piece of electronic equipment. In that case there are cost savings resulting when there is a smaller number of expensive measuring devices needed in the operating room. The invention also enables one to save space in the operating room, since only one piece of equipment

is needed for making the measurements. In a narrow operating room full of instruments the saving of space is a remarkable improvement.

SUMMARY OF THE INVENTION

The invention enables one to make measurements of the electric activity of a patient with one piece of equipment. The equipment comprises ten signal conductors which are used together in different measurements in the same equipment.

The invention relates to a method for a medical monitoring system. In the method, the functions of a patient are measured, and the changes in the electric activity of the patient are observed. In particular, in the invention, the electric activity of a patient is measured, and an electrocardiogram (EKG), electroencephalogram (EEG), and a signal (IKG) from an impedance cardiograph are taken with one piece of equipment.

In one embodiment of the invention, ten conductors are used for the observation and measuring of the patient´s electrocardiogram (EKG), electroencephalogram (EEG), and impedance cardiograph signal (IKG). By means of the conductor configuration it is possible to select the measurement to be made. On the other hand the measurement to be made may be selected by a switch. In one embodiment of the invention, when measuring the electrocardiogram (EKG) the selector switch is turned into a first position. In one embodiment of the invention, when measuring the electroencephalogram (EEG) the selector switch is turned into a second position. In one embodiment of the invention, when measuring the impedance cardiograph signal (IKG) the selector switch is turned into a third position.

In one embodiment of the invention, the channels transferring the electroencephalogram (EEG) are

changed to a bigger resistance by means of a control device.

In one embodiment of the invention, the electric activity of the muscles in the facial region are being monitored (EMG).

In one embodiment of the invention, from the observed signals, an index describing the depth of the anesthesia is calculated. This enables one to make sure of the quality of the anesthesia during the operation.

In one embodiment of the invention, the electroencephalogram channels (EEG) use the same neutral electrode with the electrocardiogram channels (EKG).

In one embodiment of the invention, based on the impedance relations of the electrodes, the configuration of the electrodes is estimated, in which case it is possible to judge what measurements are supposed to be made.

In one embodiment of the invention, from a 5-lead electrocardiogram (EKG), a 3-lead electrocardiogram (EKG) and a 2-lead electroencephalogram (EEG) are derived.

In one embodiment of the invention, the medical monitoring system of the invention comprises signal conductors, which, according to the standard placement of electrodes, are connected to the measuring electrodes attached to the patent, and which each signal conductor comprises a first connector apparatus; and measuring equipment which comprises electrocardiogram (EKG), electroencephalogram (EEG), and impedance cardiograph signal equipment (IKG). According to the invention, the equipment comprises a selector switch for selecting the measurement type so that in the first position of the switch, the signal conductors are connected to the electrocardiogram equipment (EKG), in the second position of the switch, the signal conductors are connected to the electroencephalogram equipment (EEG), and in the third position of the switch,

the signal conductors are connected to the impedance cardiograph signal equipment (IKG).

In one embodiment of the invention, the system comprises a preamplifier unit which may be used to monitor the 12-switched electrocardiogram (EKG), or the limb or full-length impedance cardiograph signal (IKG) of the 5-lead electrocardiogram (EKG) so that the amplifier channels of the chest wiring of the 12-lead electrocardiogram (EKG) transfer to monitor the limb or full-length impedance cardiograph signal (IKG).

In one embodiment of the invention, the system comprises a preamplifier unit which in which the configuration of the electrodes is estimated based on the impedance relations of the electrodes.

As compared to prior art, the present invention has the advantage that several measurements may be made without having to change the preamplifier or even the signal conductors. The invention also enables one to save space in a narrow operating room, since only one piece of equipment is needed. There are also cost savings resulting, since shared measuring equipment is more advantageous than separate pieces of measuring equipment. Further, the possibility of making several measurements with one piece of equipment lowers the threshold to use the measurements.

LIST OF DRAWINGS

In the following section, the invention will be described by the aid of a few examples of its embodiments with reference to the accompanying drawing, in which:

Fig. 1 represents one prior-art placement of electrodes;

Fig. 2 represents one prior-art placement of electrodes;

Fig. 3 represents one illustration of the system in accordance with the invention;

Fig. 4 represents one flow chart illustrating the method of the invention;

Fig. 5 represents one circuit diagram of the invention;

Fig. 6 represents one circuit diagram of the invention;

Fig. 7 represents one placement of the electrodes and conductors in accordance with the invention; and

Fig. 8 represents one placement of the electrodes and conductors in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

Fig. 3 represents one system of the invention. The measuring electrodes RA, LA, RL, LL, V_1, V_2, V_3, V_4, V_5, V_6 placed on the patient P are connected to the switch K. The switch K is further connected by a first connection I to the measuring equipment of the electrocardiogram EKG, by a second connection II to the measuring equipment EEG of the electroencephalogram, and by a third connection III to the measuring equipment IKG of the impedance cardiograph signal. The switch K may be used to select what measurement each time is used. The switch K and the pieces of measuring equipment EKG, EEG, and IKG form one piece of integrated measuring equipment 30.

Fig. 4 represents one diagram illustrating the method of the invention. At first in the method, the measuring electrodes are placed on the patient. After this, the desired measurement is selected by a switch. If one wishes to measure the EKG, then the switch is turned into position I, points 42 and 43. If it is the EEG that is wished to be measured, then the switch K is turned into position II, points 45 and 46.

If it is the IKG that is measured, then the switch K is turned into position III, points 48 and 49.

Fig. 5 represents one circuit diagram in accordance with the invention. The figure shows the measuring of a 12-switched EKG and EEG. The measuring electrodes RA, LA, RL, LL, V_5 needed in the measuring of a 5-switched EKG are connected via protective resistors $R_{1...5}$ to amplifiers $A_{1,3,5,7,9}$. The signal is further amplified by a second row of amplifiers $A_{2,4,6,8}$, from which there is a connection to a multiplexer MP. Further, from the four measuring electrodes RA, LA, RL, LL, a sum function SUM is calculated. From the multiplexer MP there is a connection via an analogy digital converter to a micro processor PROC. Besides the aforementioned measuring electrodes, for the measuring of a 12-switched EKG and EEG, the measuring electrodes V_1, V_2, V_3, V_4, V_6 are needed that are connected via the protective resistor $R_{6...10}$ to the amplifier $A_{10,12,14,16,18}$. The signal is further amplified by a second row of amplifiers $A_{11,13,15,17,19}$, from which there is a connection to the multiplexer MP. From the multiplexer MP there is a connection via the analogy digital converter to the micro processor PROC.

Fig. 6 represents one circuit diagram in accordance with the invention. The figure shows the measuring of a 12-switched EKG and IKG. For the measuring of a 5-switched EKG, the measuring electrodes RA, LA, RL, LL and V_5 on the left-hand corner of the figure are needed that are connected via protective resistors $R_{1,2,4,6,7}$ to amplifiers $A_{1,3,5,7}$. The signal is further amplified by a second row of amplifiers $A_{2,4,6,8}$, which are further connected to the multiplexer MP. From the two measuring electrodes RA and LA there is a connection via protective resistors $R_{3,5}$ to the standardized measuring circuit SRIC of the impedance of breathing which is further connected to the multiplexer MP. The multiplexer MP is further connected via

an analogy digital converter ADC to the micro processor PROC. Besides the aforementioned measuring electrodes, for the measuring of a 12-switched EKG or IKG, the measuring electrodes V_1, V_2, V_3, V_4, V_6 are needed that are connected via protective resistors $R_{8,10,12,14,16}$ to amplifiers $A_{10,12,14,16,18}$ that are further connected to the multiplexer MP. From the multiplexer MP there is a connection via the analogy digital converter ADC to the micro processor PROC. The micro processor PROC is connected to high-frequency current drivers HFCD from which there is further a connection to the measuring electrodes V_1 and V_2 via the protective resistors $R_{9,11}$. The measuring electrode V_4 is connected via the protective resistor R_{15} to the high-frequency amplifiers and to the observation circuit of the synchrone, from which there is a connection via the analogy digital transformer ADC to the micro processor PROC.

Fig. 7 represents one placement of electrodes and conductors in accordance with the invention. The switching of the figure may be used for the observation of a 5-switched EKG. Connected to the amplifier AMP are the measuring electrodes V_1 and V_2. Further, to a high-frequency current source CS (20-1000 kHz) there are connected the measuring electrodes V_6 and V_5.

Fig. 8 represents one placement of electrodes and conductors in accordance with the invention. The switching of the figure may be used for the measuring of a 5-switched EKG. Connected to the amplifier AMP are the measuring electrodes V_1, V_2, V_5, V_6, and RL.

The invention is not restricted merely to the examples of its embodiments referred to above, instead many variations are possible within the scope of the inventive idea defined by the claims.